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(54) Foamed phenolic board laminate

(57) An insulating board of excellent properties is made from a core of foamed phenol-formaldehyde resin which has a closed cell content of at least 85% and on at least one face a glass fibre tissue or cloth laminated to the core using a water-based natural rubber adhesive. Essential properties relating to the water absorption, thermal conductivity, flexural strength, compressive peel strength and delamination peel strength of the laminate are specified. The laminate has excellent fire resistance and may comprise, in the adhesive, a fungicide and an anti-oxidant.

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SPECIFICATION
Phenolic board laminate

This invention concerns a laminated insulation board.

It is known to make insulation boards from foamed plastics, and some of these are laminated with other materials to give properties desirable for use in building or construction work. In particular, it is known to use phenol-formaldehyde boards in roof insulation, but it is believed that commercially available phenol-formaldehyde boards have up to now been of open-cell construction.

The present invention provides a laminated insulating board comprising an insulating core of foamed phenol-formaldehyde resin which has a closed cell content of at least 85% and on at least one face a glass fibre woven or non-woven cloth or tissue laminated to the core with a water-based natural rubber latex adhesive, the laminate having a water absorption of not more than 10% v/v, a thermal conductivity (k-value) of less than 0.035 W/m°C a flexural strength of at least 50×10^4 N/m^2, a tensile strength of at least 30×10^4 N/m^2, a compressive strength of at least 20×10^4 N/m^2 and a delamination peel strength of at least 200 N/m at room temperature.

It is believed that the combination of properties essential to success in practical usage can only be obtained with a laminate as specified above, and it is essential to use the natural rubber adhesive, to achieve a satisfactory product. It is preferred that the laminate of the invention is a sandwich form, in that it is laminated with glass fibre on two opposing major faces.

The core of foamed phenol-formaldehyde may be manufactured without difficulty; several manufacturers sell phenol-formaldehyde resoles which are intended for foaming. A blowing agent, such as a "Freon" Registered Trade Mark blowing agent, is conventionally used, as is a hardener, such as an acid, e.g. hydrochloric acid. It is advantageous to use a cell control agent, and a silicone oil surfactant may be used. As has been stated above, a very high closed cell content is believed essential, and manufacture may be controlled in known manner to achieve this.

The glass fibre cloth or tissue is preferably a non-woven tissue, which is commercially available. The preferred tissue has a thickness of 0.25 to 0.60 mm, a weight of 40 to 80 g/m^2 and a tensile strength of 15 to 40 N/m^2. The tissue improves the strength and the dimensional stability of the insulating board, yielding results in combination with the rubber adhesive which are unexpectedly good.

It is essential to use a natural rubber latex adhesive, which may be thickened to a convenient viscosity (e.g. to 5,000 — 15,000 cps at 20°C for application using a roller coater applicator) using a polyacrylate thickening agent. Since insulation boards are frequently exposed to damp, for example from condensation, it is preferred to incorporate a fungicide to prevent fungal growth and possible loss of strength. Also, since the insulation boards of the invention may be exposed to high temperatures, by reason of their being applied to a structure using molten bitumen (at about 150°C) or because of solar gain, it is preferred to stabilise the natural rubber adhesive with the addition of an anti-oxidant. The adhesive has to give a high bond strength between the phenolic foam core, which is of low density, dusty and friable, and the glass fibre cloth or tissue. The bond has to withstand wind suction on flat roofs in severe gales, and it has been found that a minimum peel strength of 200 N/m is required. In addition, the adhesive must exhibit minimum degradation at temperature extremes of −10°C and +90°C and be unaffected by moisture and dilute acids; it must also withstand contact with hot melt bitumen and asphalt at temperatures up to 250°C.

An extremely wide selection of adhesives were assessed for compliance with the above requirements, including essentially all commercially available elastomeric polymers, vinyl — and acrylic — based adhesives etc. To the surprise of the inventors, only natural rubber was found to be totally suitable, although of course other adhesives met some or almost all of the criteria. Most of the failures were caused in a test involving contact with hot bitumen or a 90°C high temperature delamination test.

It was decided that a water-based adhesive was required for both economic reasons and for practical usage; six were tested for their ability to bond glass fibre tissue to phenolic foam and durability when subjected to specific ageing tests. The results for peel strength are given in the table below.

Peel Strength (N/m)	Adhesive					
	Poly Vinyl Acetate	Styrene Butadiene Rubber	Nitrile Rubber	Neoprene Rubber	Acrylic	Natural Rubber
At ambient	94	300	640	172	194	325
After 30 days at 90°C	143	21	150	120	185	105
After 30 days at -10°C	110	142	200	160	90	320
After 30 days cycle test (Note)	41	24	322	120	189	305

Note: The cycle test involves holding the test pieces for 24 hours at 90°C, 50°C and 100% Relative Humidity and at -10°C respectively for a total period of 30 days.

Nitrile rubber performed extremely well in these peel strength tests: it was, however, the poorest of the six adhesives in shear strength and could not therefore meet the overall requirements set by the inventors. Many commercial adhesives failed to give a bond strength of even 50 N/m or broke down on contact with water, or could not withstand hot bitumen at 250°C and so were not evaluated to the same extent as the six mentioned in the table above.

The invention will now be illustrated by means of an example.

A phenol formaldehyde resole resin of low reactivity and low free phenol content, having a specific gravity of 1.20 to 1.25 g/cc and a viscosity at 20°C in the range 3,000 to 6,000 cps, is thoroughly mixed in a batch with a surfactant such as a long chain fatty acid or a silicone, an acid hardener (conveniently hydrochloric acid or p-toluene sulphonic acid) and a low boiling point liquid blowing agent, such as pentane or trichlorofluoromethane. The proportions of the ingredients are:

P/F resin	30 Kg
Surfactant	0.3 Kg
Hydrochloric Acid	3 Kg
Pentane	2 litres.

The batch mixture is poured into a mould of dimensions 1.25 m × 0.65 m × 1 m which is then heated at 40 — 50°C for 3 — 4 hours. The batch foams and hardens, and the foam block resulting is removed from the mould and allow to cool for 2 days. The block is then cut into panels or boards of size 1.2 m × 0.6 m × 25 mm. The dry foam density is 35—40 Kg/m^3.

A thickened natural rubber adhesive, having a viscosity in the range 5,000 — 15,000 cps at 20°C is applied on both major sides of individual foam boards by a roller coater. To the adhesive is applied a glass fibre non-woven tissue of 0.40 mm thickness, 60 g/m^2 weight and having a tensile strength of 25 × 10^2 N/m, to give a laminated foam board.

The laminated board was tested for physical properties in comparison with an unlaminated board.

Test	Foam Board	Laminated Board
Compressive Strength/Puncture (1) (N/m^2)	22 x 10^4	22 x 10^4
Puncture Resistance (1) (N/m^2)	Very low	43 x 10^4
Flexural Strength (1) (N/m^2)	30 x 10^4	60 x 10^4
Tensile Strength (1) (N/m^2)	18 x 10^4	35 x 10^4
Dimensional Stability (2) (%)		
at 50°C	−0.1	+0.02
70°C	−0.5	+0.02
90°C	−0.6	−0.04
50°C/100% relative humidity	−0.1	−0.02
Total Shrinkage, 24 hrs @ 70°C (1)	0.7	0.1
Laminate Flexing test (3)		
at 0°C (delamination)	-	None
at 20°C (delamination)	-	None
Foam Porosity		
Water absorption (3) (% v/v)	-	7.8
Vapour transmission (4) perm/inch	-	1.9
Peel Strength (5) (N/m)		
At Ambiant Temp.	-	220
After 30 days at -10°C	-	215
30 days cycle test (6)	-	227
After 30 days at 90°C	-	60
ditto, using antioxidant in adhesive	-	180

Notes:

(1) Tests from British Standards 3927 and 4370.

(2) B53927, modified to include greater number of temperatures.

(3) Test devised by inventors.

(4) B52972

(5) ASTM D773—47

(6) 24 hrs at 90°C, 24 hrs at 50°C/100% RH and 24 hrs at −10°C, for total period of 30 days.

It will be readily seen from the above that the laminated board according to the invention shows significantly superior properties to those of the unlaminated board, and the improvement is greater than could be expected from a consideration of the properties of the glass fibre tissue.

In addition, the laminated board according to the invention shows very good resistance to heat and fire. It will char rather than burn. Unlike many insulating plastics foams, it will not melt or produce dense smoke, nor will it give off amines, cyanides, sulphur dioxide or other toxic gases. Tested according to B5476 for surface spread of flame, it achieved a nil flame spread (Class 1) and tested for ignitability it achieved the highest rating available (not easily ignitable).

Clearly, the thickness of the board, and other dimensions, can be varied according to the requirements of the user.

CLAIMS

1. A laminated insulating board comprising an insulating core of foamed phenol-formaldehyde resin which has a closed cell content of at least 85% and on at least one face a glass fibre woven or non-woven cloth or tissue laminated to the core with a water-based natural rubber latex adhesive, the laminate having a water absorption of not more than 10% v/v, a thermal conductivity (k-value) of less than 0.035 W/m°C, a flexural strength of at least 50×10^4 N/m^2, a tensile strength of at least 30×10^4 N/m^2, a compressive strength of at least 20×10^4 N/m^2 and a delamination peel strength of at least 200 N/m at room temperature.

2. A board according to claim 1, wherein the core is laminated with the glass fibre tissue or cloth on two opposing major faces.

3. A board according to claims 1 or 2, wherein a glass fibre non-woven tissue is used.

4. A board according to claim 3, wherein the tissue has a thickness of 0.25 to 0.60 mm, a weight of 40 to 80 g/m^2 and a tensile strength of 15 to 40 N/m^2.

5. A board according to any one of the preceding claims, wherein the adhesive comprises a fungicide and an anti-oxidant.

6. A board according to claim 1, substantially as hereinbefore described.

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